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OVERALL EVALUATION OF ERTS-1 IMAGERY FOR CARTOGRAPHIC APPLICATION
(NASA # 233)

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Prepared for:

Goddard Space Flight Center
Greenbelt, Maryland 20771

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16. Abstract A sizeable number of ERTS images have been examined and evaluated for their cartographic potential. Applications defined to date include: <ul style="list-style-type: none"> o Use as map image or chart base at 1:250,000 and smaller scales. o Use as a map itself by precision (scene corrected) processing or by fitting a geodetic grid to the bulk (system corrected) image in order to comply with National Map Accuracy Standards. o Revision of line maps of 1:250,000 and smaller scale. o Planning the revision of large scale maps. o Precise and repetitive correlation of shoreline to water stage in relatively flat areas subject to inundation - thus providing some unique and potentially valuable topographic data on such areas. o Thematic mapping of water, IR reflective vegetation, snow and ice and the spatial changes to these themes. 			
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Figure 2. Technical Report Standard Title Page

Type II Progress Report

ERTS-A

- a. Title: Overall Evaluation of ERTS-1 Imagery for Cartographic Application

ERTS-A Proposal No: SR 233

- b. GSFC ID No. of P.I.: IN 014

- c. Problems:

The lack of sizeable block coverage of ERTS imagery of uniform density and contrast has precluded compilation of experimental standard map quads. The lack of RBV coverage has necessitated sole use of MSS imagery which lacks the geometric fidelity of the RBV's. The large variation in image density as recorded by the EBR as a function of illumination (sun angle) further complicates cartographic treatment. The lack of blocks of precision processed MSS imagery has also hindered cartographic research. Another problem has been the inability of the public to receive ERTS products of uniform high quality and in a timely manner thus precluding evaluation by the public which is a key part of this experiment. In general these problems are being resolved.

- d. Accomplishments and Plans:

Specific accomplishments and plans are covered by the individual cartographic experiments Nos. 116, 149, 150, 211 and 237 which in turn contribute to this investigation.

- e. Scientific conclusions and results:

Significant pertinent scientific results may be summarized as follows:

- o RBV's (bulk) have internal positional accuracy in the order of 70 meters (rms) at ground scale whereas MSS internal accuracy is in the order of 200 to 300 meters (rms). Both RBV and MSS precision processed images have internal positional accuracy within 70 meters (rms).
- o Image quality exhibited by detectability and acutance is better than expected and perhaps twice as good as would be achieved by a photographic (film) system of the same resolution. This means that ERTS imagery can be enlarged to 1:500,000 or even 1:250,000 scale and still be of optimum quality to the unaided human eye.

- o Photometric anomalies (shading) have limited RBV multispectral application but it is believed that these anomalies can be further reduced.
- o The MSS has exceptionally high photometric fidelity but the matching of adjacent scenes taken under different conditions of illumination has not been resolved.
- o MSS bands 6 and 7 have enormous potential for surface water mapping including the correlation of shorelines at various water stages. Water bodies in the order of 200 meter diameter can be detected.
- o MSS band 7 demonstrates an actual cloud penetration capability beyond which was expected. It also has delineated cultural features better than the other MSS bands under certain conditions.

f. Published articles and reports:

Papers prepared during the period are as follows:

- o Cartographic Application of ERTS Images (Colvocoresses) presented at NASA/Goddard ERTS Review on Sept. 29, 1972.
- o Cartographic Promise of ERTS-1 (Colvocoresses) presented at the ASP-ACSM Fall Technical Convention, Columbus, Ohio, Oct. 1972 (abstract attached).
- o New Photomap Products (Colvocoresses) presented at the AAAS annual meeting, Washington, D.C., Dec. 27, 1972 (abstract attached).
- o Ten Memoranda for Record EROS Cartography numbered memos EC-1-ERTS thru EC-13-ERTS. Copies of EC-2, 3, 4, 12 and 13 are attached.

g. Recommendations:

Informal suggestions and recommendations for ERTS are contained in the previously referenced memoranda. They may be summarized as follows:

- o Comparison of U.S. and Canadian approach to precision (scene corrected) processing. This item is covered in EC-2-ERTS.
- o Realignment of the sensors or spacecraft to minimize image skew (EC-3-ERTS).
- o Minor changes to precision (scene corrected) processing (EC-4-ERTS).

- o Recommendations based on ERTS-1 performance and relative to future ERTS type missions have been made to the EROS Program Office.

h. None

i. None

j. None

ABSTRACT

Cartographic Promises of ERTS

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With ERTS-A scheduled for launch during the summer of 1972, the cartographic potential of such a system deserves critical and constant evaluation. Prelaunch data must be compared with real space imagery to see to what extent the pertinent specifications have been met. The production of sample cartographic products, their distribution to the concerned public, and a careful evaluation of user reaction are all involved. The potential of an ERTS type satellite to meet operational needs related to cartography are also examined.

Presented at the ACSM-ASP Fall Convention, Columbus, Ohio, Oct. 11, 1972.

ABSTRACT

NEW PHOTOMAP PRODUCTS

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Producing conventional topographic line maps is a relatively slow and expensive process and many areas of this country are changing faster than we can record the changes on the line maps. The use of the photoimage, in map form, provides a possible solution where the resulting photomap will serve as an up to date complement to the line map.

Space systems such as ERTS provide imagery which is ideal for photomapping at the smaller scales. Space imaging systems will probably never fully take the place of conventional aerial photography, but the two modes effectively complement each other and together provide man's first real opportunity to systematically monitor and map the world's resources and changing environment.

Presented at the annual AAAS Meeting, Washington, D.C., Dec. 27, 1972.



United States Department of the Interior

GEOLOGICAL SURVEY
WASHINGTON, D.C. 20242

October 5, 1972

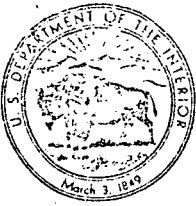
Memorandum for the Record (EC-2-ERTS)

By: Cartography Coordinator, EROS Program

Subject: Preparation of a precision (map corrected) ERTS image for comparison of U.S. and Canadian systems

The undersigned and Larry Morley, Director of the Canadian Center for Remote Sensing (CCRS) after consultation with NASA officials have agreed on the following action relative to this subject:

1. Selection of the ERTS frame covering the Olympic Peninsula and Vancouver Island on orbit 98 (July 30). This has the Canadian designation of CCRS 107-8366.
2. Band of primary concern is No. 5 (red MSS).
3. CCRS (Morley) will send USGS (Colvo) 1:250,000 scale maps and any larger scales available covering the Canadian area of the scene.
4. USGS (Burger) will send 1:250,000 scale gridded maps of the U.S. area plus control data to CCRS (Morley).
5. CCRS will map control this image and furnish two transparencies and 2 prints at 1:1,000,000 scale to USGS.
6. NASA (Goddard) at USGS request, and with control of the Canadian portion furnished by USGS, will precision process this same scene (probably all bands) and furnish USGS with four sets of transparencies and prints thereof. This precision process should include the UTM X's across the image.
7. USGS will furnish CCRS with two sets of the NASA developed materials.
8. CCRS and USGS will independantly evaluate the U.S. and Canadian products for spatial accuracy and (nongeometric) image quality and exchange results.
9. USGS will advise NASA as to the results of this examination and initiate any technical discussions or actions that might appear warranted relative to precision processing.



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GEOLOGICAL SURVEY
WASHINGTON, D.C. 20242

October 6, 1972

Memorandum for the Record (EG-3-ERTS)

By: Cartography Coordinator, EROS Program

Subject: Suggested realignment of ERTS imagery

This office after examining ERTS-1 RBV and MSS imagery suggests the following relative to ERTS-B and if possible for ERTS-1.

That the spacecraft (or sensors) be oriented (skewed) at about 3° to the right of the direction of the spacecraft velocity vector as viewed from the spacecraft. This would result in a mean compensation for earth rotation and the virtual elimination of the existing skew to the MSS frame and the step over between RBV images in the midlatitudes. Such action would aggravate the skew on the ascending node which is of no current concern and would introduce 3° of skew at maximum inclination (81°) which is an area of lesser concern and high redundancy.

A 3° spacecraft skew would still produce an MSS frame skew of slightly over 1° at the equator which would mean that skew in excess to this amount would occur only at the extreme latitudes.

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cc:

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United States Department of the Interior

GEOLOGICAL SURVEY
WASHINGTON, D.C. 20242

October 12, 1972

Memorandum for the Record (EC-4-ERTS)

By: Cartography Coordinator, EROS Program

Subject: Comments on NASA scene corrected (precision processed) products

This office has recently received a complete set of precision processed images of ERTS from E-1002 - 18131 (Lake Tahoe). Based on an examination of this material, the following technical comments are offered:

1. The precision process appears to be functioning properly and the positional accuracy is probably better than can be measured, due to the limitation imposed by image quality.

2. Non-geometric image quality appears to be as predicted by NASA with an approximate 100% loss in "resolution" as compared to the system corrected (bulk) processed. The incremental block shading is distracting and does somewhat reduce image quality, however, in the color composite version this block shading effect is considerably reduced.

3. The use of band 7 in creating the MSS color composite creates a rather serious problem in that water boundaries have "bloomed" and thus the shorelines have lost their geometric (as well as photometric) fidelity. Band 7 at lower exposure through the negative or band 6, also controlled to avoid over-exposure is suggested.

4. The printing of external and internal ticks appears generally good although the only version seen to date involved only the UTM ticks (X's) within the format. One UTM X (Zone 10, 7530) failed to print on all versions. If software will permit, the printing of UTM crosses at the zone boundary (120° in this case) is also desirable as this would identify the boundary between zones 10 and 11.

5. The precision processed product with internal X's as produced by NASA is a cartographic product which, at least in the Tahoe scene, meets National Map Accuracy Standards for the 1:1,000,000 scale. Image quality rather than geometry appears to be the limiting factor and of course all possible steps should be taken towards its improvement.

6. The best bands for precision processing are believed to be MSS 5, MSS 6 (or 7) and the MSS color composite (modified as indicated). These products should provide a valuable geometric base for all who wish to precisely relate ERTS imagery to the figure of the Earth.

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United States Department of the Interior

GEOLOGICAL SURVEY
WASHINGTON, D.C. 20242

November 29, 1972

Memorandum for the Record (EC-12-ERTS)

By: Cartography Coordinator, EROS Program

Subject: Application of ERTS imagery to delineation of controlled water bodies

ERTS imagery of Oct. 11, 1972 of Northern Virginia clearly indicates the extent of the new reservoir on the North Anne (Anne Lake) located 30 miles NNW of Richmond. Existing aerial photography flown in April 1972 had delineated a much smaller areal extent to the reservoir which to date has not been mapped. The number of large scale quads affected by this reservoir had not been determined but rough plotting of the reservoir from the ERTS imagery quickly showed that the reservoir extended well into 5 7.5 minute quads where several miles of new shoreline are involved in each quad and thus justifies their revision. It was further determined that on Oct. 11 the reservoir was about 8 feet below the mappable pool level. Since the water elevation of controlled water bodies is generally recorded on a continuous basis there is a potential application of ERTS to the contouring of reservoir basins. This application should apply to the quantitative determination of siltation in the larger reservoirs which is a matter of considerable economic importance.

The ERTS imagery in question will be enlarged and further analyzed to determine the extent to which it can contribute to the actual revision of the large and medium scale maps in question. A report on this matter will be made by William Kosco, Principal Investigator of experiment No. 499, Map Revision from ERTS-A data.

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United States Department of the Interior

GEOLOGICAL SURVEY
WASHINGTON, D.C. 20242

January 10, 1973

Memorandum for the Record (EC-13-ERTS)

By: Cartography Coordinator, EROS Program

Subject: Potential capability of ERTS for delineating water boundaries at various stages in areas subject to inundation (analogue approach)

Background

This memorandum supplements EC-12-ERTS dated November 29, 1972, which briefly indicated the potential of ERTS for delineating the shores of controlled water bodies. On October 11, 1972, ERTS imagery of Northern Virginia was received from NASA Goddard in p-1 (first generation positive) form for the various MSS bands as recorded by the Electron Beam Recorder. The p-1 MSS band 6 covering Lake Anna (a new nuclear power plant facility 20 mi SW of Fredericksburg) was processed on a precision (Beacon) enlarger and brought up to scales of 1:250,000 and 1:24,000 in negative transparency form. The latter represents a 140.4X enlargement from the original 70 mm format at 1:3,369,000 scale. At 1:24,000 scale, picture elements (pixels) are more or less defined, and those pixels which record the water-land boundary can generally be identified inasmuch as water gives a basically clear (very low and uniform density) response on the negative transparency. Band 6 was used for this experiment because the land-water interface on this water body is well defined and it was feared that the high contrast of band 7 might result in displacement of the shoreline due to the spread function (blooming or halation) that frequently is encountered in the enlarging process. NASA defines the instantaneous field of view on the MSS scanner as 79 m at ground scale; however, the net pixel size as recorded appears somewhat smaller. On the 1:24,000-scale enlargement these net pixels measured approximately 69 m (along track) by 60 m (cross track). This pixel is an apparent or net instantaneous field of view as recorded.

Relative Accuracy of Water Boundaries

Based on an analysis of this enlargement and comparing it to aerial photography, we believe that the shoreline, sizeable bridges, and other related structures can generally be defined to within a pixel, except in areas where the water-body width becomes somewhat less than two pixels (130 m) and thus may not be properly recorded as a distinct water signature. In practice it is believed that arms of water bodies as narrow as 100 m will still provide a meaningful signature and that water boundaries can be mapped from such materials within a relative accuracy of 100 m (rms). The term relative accuracy as used herein refers to the best planimetric fit that can be made with a portion (say one sixteenth) of an ERTS scene. This, in effect, requires that the area has been previously mapped and that there are image identifiable land marks on the map. Thus, relative accuracy is applicable to the problems of map revision as opposed to absolute accuracy which is related to map compilation. Unless otherwise stated, the probability associated with accuracy is that of the root mean square (rms) or standard error assuming normal (Gaussian) error distribution. A detailed analysis of the capability of the ERTS imagery to delineate the shores of Lake Anna is being undertaken and will be reported on at a later date.

Band 7 of MSS defines water boundaries at higher contrast than band 6, and even in turbid or very shallow areas the boundary is distinct. Dr. Larry Lepley of ARETS states that MSS-7 images very shallow water over a white bottom in the large tailings ponds at Twin Buttes, south of Tucson, with a distinct signature. Apparently water of only a few mm thickness effectively absorbs this IR (0.8-1.1 μm) band. Thus in areas with slopes as low as 1:1,000, the boundary would still be sensed by the scanner to within a meter or so of the actual boundary if the spot size were that small. The upper reaches of reservoirs and coastal areas frequently have slopes in the order of 1:1,000, and therefore the MSS bands 6 and 7 become powerful topographic mapping tools in such areas. If relative position to within 100 m is maintained, this is equivalent to depth determination of 0.1 m. With a first order stereoplotter, aerial photographs taken no higher than 1,000 m would have to be used to achieve such vertical accuracy, which simply isn't practical in most cases. Of course, aerial photographs taken when the water is at the desired level would provide a far more accurate delineation, but obtaining aerial photographs of water bodies and coastal areas at all of the various levels desired hardly seems practical.

Areas of Potential Application

With repetitive coverage possible every 18 days, an inventory of the land-water interface at various known or determined water elevations can be made. Assuming only 50% success due to visibility limitations, 180 such records would be accumulated each year. Since the ERTS phenomenon is well known and reliable, a manager of a controlled reservoir might alter the water level (within limitations) to obtain the water-land interface at some specified critical contour. This could appear to have at least two practical applications: First, the delineation of various water levels (contours) in the flatter areas as a new reservoir is filling, and, second, the determination of elevation by defining various water levels in an old reservoir and comparing them with original topographic data. In coastal areas the tidal stages imaged by ERTS will, of course, be random, but the images can be accurately correlated to stages by at least two different methods: First, recording tide gauges provide stage data at specific points. Second, selected image-identifiable points in gently sloping (say 1:1,000) areas could be precisely surveyed by conventional leveling from known benchmarks. Correlating ERTS imagery to the image-identifiable points would provide stage data in the order of 0.1 m. By the use of even flatter areas of known precise elevations, it is believed that this accuracy could be exceeded in certain areas. Of course the recorded stage data would reflect the effect of local hydraulic gradients as well as tide stage itself, and the density of correlation points would govern the accuracy of stage determination. It should also be noted that this application is valid only in areas of open water, because vegetation, or or above the water surface, more or less destroys the water-land interface signature.

The principles, techniques, and limitations discussed above also apply in areas subject to natural flooding. However, in such areas, hydraulic gradients are normally present and must be considered if the land-water interface is to be used to determine a stage, or if an image-identifiable point is to be used for precise flood-level determination at other than points of known elevation.

Summary

ERTS MSS bands 6 and 7 provide distinct water-land interfaces with an apparent relative horizontal accuracy of within 100 m (rms). The water bodies must have a minimum lesser dimension in the order of 100 m and probably several hundred meters as a greater dimension to be recorded with a signature unique to water bodies. Investigation by the Corps of Engineers indicate water bodies as small as 8 acres (equivalent to ~200 m diameter) are being detected with good reliability on ERTS.

The precision indicated is based on optimum film processing from the original MSS-6 positive recorded by the Electron Beam Recorder. It is noted that all photoprocessing involves image degradation, and the degree to which the precision indicated is reached will depend on the generation and quality of the image obtained and any subsequent image processing applied. Those who have the capability of processing MSS digital data, should obtain comparable results. However, it should be noted that for either the analogue or digital approach no claims are made for absolute positioning of the land-water interface. Studies pertinent to this matter are underway and will be reported on separately.

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